FINAL EXAM

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SECTION :- B

SUBMITTED TO :- SIR WAHEED

SUBJECT :- FLUID MECHANICS

DEPARTMENT :- CIVIL ENGINEERING

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QUESTION :- 01 (A)

Define Total Energy head and Various forms of Energy Head with Mathematical Equations.

Total Energy Head :-

It is the sum of all energy heads at a point in a fluid.

Forms of Energy Head :-

There are various form of energy head which are as follows.

(i) Kinetic Head

(ii) potential Head.

(iii) pressure Head.

★ Kinetic Head :-

It is the kinetic Energy per unit weight of the fluid.

Kinetic Head is also known as velocity Head because it is due to motion of the fluid.

Mathematical form :-

$$\frac{K.E}{W} = \frac{\frac{1}{2}mv^2}{mg}$$

$$\frac{K.E}{W} = \frac{1}{2}\frac{v^2}{g}$$

Unit :-

is meter (m).

★ potential Head :-

It is the potential Energy per unit weight of the fluid. or The Height of fluid is (p.H).

Mathematical form :-

$$\frac{P.E}{W} = \frac{mgh}{mg} = h \quad \left(\because = \frac{\text{potential Energy}}{\text{Fluid weight}} \right)$$

$$\frac{P.E}{W} = h$$

Unit :-

is meter (m).

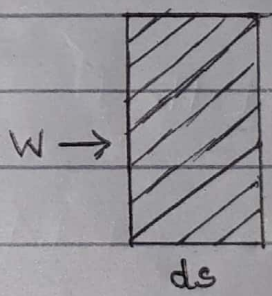
pressure Head :-

The Vertical Height of the free Surface above any point in a liquid at rest is pressure Head.

(OR)

Level of fluid due to pressure exerted by fluid.

Mathematical Form :-



As $\frac{\text{work}}{w} = \frac{F \cdot ds}{W}$

$$= \frac{P \cdot A ds}{W}$$

$$= \frac{P \cdot V}{W}$$

$$\text{pressure Head} = \frac{P}{\gamma} \quad \because \gamma = \frac{W}{V} \Rightarrow \frac{1}{\gamma} = \frac{V}{W}$$

Unit :-

is meter (m).

QUESTION :- 01(B)

Define Hydraulic grade line, Energy Line and Hydraulic radius.

★ Hydraulic grade line :-

The Hydraulic grade Line is a Line representing the total Head available to the fluid - minus the velocity head. It does not Include the kinetic head or velocity head.

Expressed as :-

$$HGL = \frac{P}{\gamma} + h$$

where

HGL = Hydraulic Grade Line (m fluid Column).

The hydraulic grade line lies one velocity head below then the energy Line.

The Energy Line :-

The Energy line is a Line that represent the total head available to the fluid.

Expressed as :-

$$EL = H = \frac{P}{\gamma} + \frac{V^2}{2g} + h = \text{Constant along a Stream Line}$$

where,

EL = Energy line (m fluid Column)

⇒ For a fluid flow without any loses due to friction (major loses) or Components (minor Loses) - the Energy Line would be at Constant Level. In practical world the energy line Decreases along the flow due to Loses.

⇒ A turbine in the flow reduces the energy line and a pump or fan in the Line increases the energy Line.

* Hydraulic Radius :-

The ratio of the Cross-Sectional Area of a channel or pipe in which a fluid is flowing to the wetted perimeter of the Conduct is Called Hydraulic Radius.

Mathematical Form :-

$$\text{Hydraulic Radius} = \frac{\text{Cross-Sectional Area}}{\text{Wetted perimeter}}$$

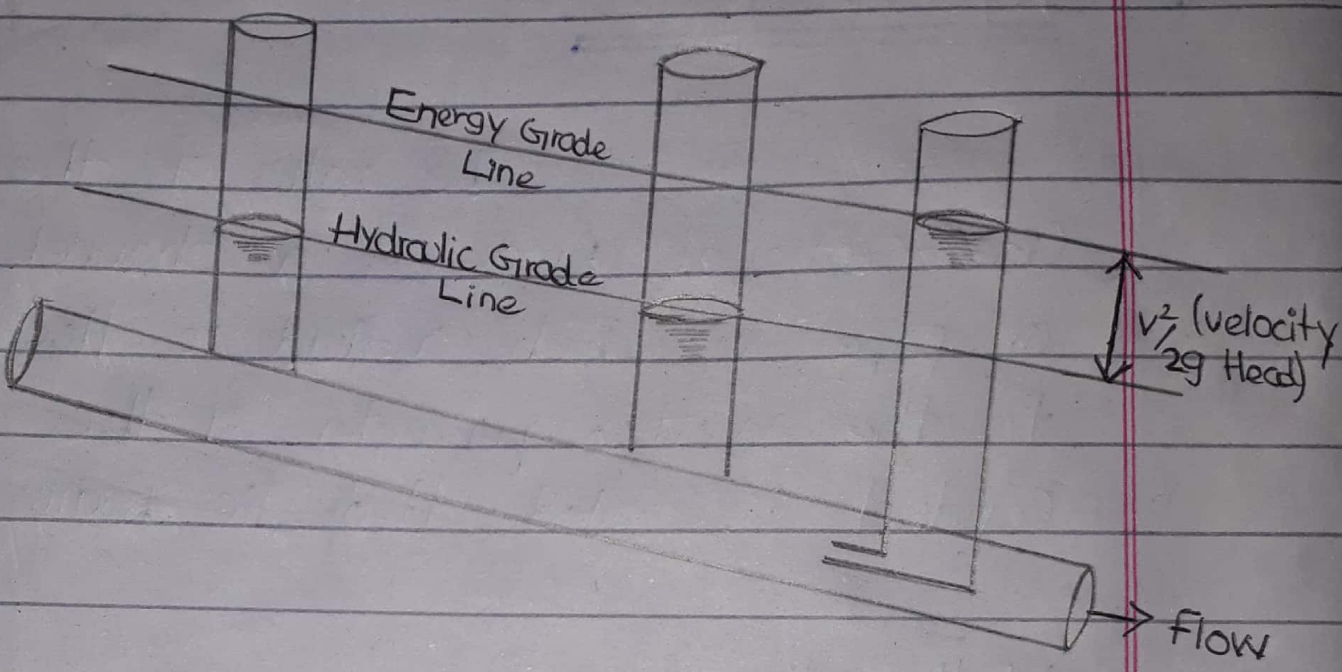
$$R = \frac{A}{P_W} \quad \text{or} \quad R = \frac{(\pi/4\, D^2)}{\pi D}$$

$$R = \frac{D}{4}$$

Where,

R = Hydraulic Radius
A = Cross-Sectional Area.
P_W = Wetted perimeter
D = Diameter of pipe.

Diagram :-


Energy Grade
Line
Hydraulic Grade
Line
$v^2/2g$ (velocity Head)
Flow

QUESTION :- 2(A)

Calculate the total energy per unit weight of water if it is flowing with a mean velocity of 2 m/s under a pressure of 300 kpa. The Height above the datum is 5 m.

Given Data :-

Velocity, $V = 2 m/s$.

pressure, $P = 300 \, Kpa$

$Z = 5m$

$g = 9.8 ms^{-2}$

$\gamma = \rho g = 1000 \times 9.81$

$= 9810 \, N/m^3$.

Required Data :-

Total Energy Per Unit Weight, H = ?

Solution :-

As We know that

$$H = Z + \frac{1}{2}\frac{V^2}{g} + \frac{P}{\gamma}$$

Putting values, we get

$$H = 5 + \frac{1}{2} \times \frac{(2)^2}{9.81} + \frac{300 \times 10^3}{9810}$$

$$H = 35.784 \text{ Nm/N or Joule/N}$$

Result :-

Hence $H = 35.784$ Nm/N or J/N.

QUESTION :- 2(B)

A tapering pipe is having - - - -
- - - - - - head loss is negligible.

Given Data :-

Diameter, d_1 = 300mm = 0.3m

Diameter, d_2 = 200mm = 0.2m

pressure = P_1 = 300 kpa = $300 \times 10^3\ N/m^2$

P_2 = 120 kpa = $120 \times 10^3\ N/m^2$.

Flow Rate, $Q = \frac{400}{1000}\ m^3/sec = 0.04\ m^3/sec$.

Required :-

Datum = Z = ?

Solution :-

As we know that

$$A_1 = \frac{\pi d_1^2}{4}$$

$$= \frac{3.14 \times (0.3)^2}{4}$$

$A_1 = 0.07065 m^2$

$$A_2 = \frac{\pi d_2^2}{4}$$

$$A_2 = \frac{3.14 \times (0.2)^2}{4}$$

$A_2 = 0.0314 \ m^2$

Now, As we know that

$Q = V_1 A_1$

$$V_1 = \frac{Q}{A_1}$$

$$V_1 = \frac{0.04}{0.0706}$$

$V_1 = 0.5661 \ m/s$

And,

$$V_2 = \frac{Q}{A_2}$$

$$V_2 = \frac{0.04}{0.0314}$$

$V_2 = 1.2738 \ m/s$

Now,

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$$

where $Z_1 = 0$

$\gamma = 9810$

putting values

$$\Rightarrow \frac{300 \times 10^3}{9810} + \frac{(0.566)^2}{2(9.81)} + 0 = \frac{120 \times 10^3}{9810} + \frac{(1.27)^2}{2(9.81)} + Z_2$$

$$\Rightarrow 30.597 = 12.314 + Z_2$$

$$\Rightarrow Z_2 = 30.597 - 12.314$$

$$\Rightarrow Z_2 = 18.282 \text{ m}$$

Result :-

Hence $Z_2 = 18.282$ m

QUESTION :- 3

A 500m Long 0.2m diameter pipe transport an oil of Specific Gravity . . . . reynold's number ?

Given Data :-

Length of the pipe , $L = 500m$
Diameter , $d = 0.2m$
Specific Gravity of oil = 0.9
Flow rate , $Q = 0.06 \ m^3/s$
Viscosity , $\mu = 6 \times 10^{-5} \ Ns/m^2$.
Density , $\rho = 0.9 \times 1000 = 900 \ kg/m^3$

Solution :-

Required :- pressure loss

As we know that,

$$\nu = \frac{\mu}{\rho}$$

$$= \frac{6 \times 10^{-5}}{900}$$

$$\nu = 6.67 \times 10^{-8} \ m^2/s.$$

Now we have to find "v".

$$V = \frac{Q}{A} \quad - (1)$$

Now for Circular pipe,

$$A = \frac{\pi d^2}{4}$$

$$\Rightarrow A = \frac{3.14 (0.2)^2}{4}$$

$$A = 0.0314 \ m^2$$

putting values in eq (1)

$$V = \frac{0.06}{0.0314}$$

$$\Rightarrow \boxed{V = 1.91 \ m/s}$$

Now we know that

$$R = \frac{V \times d}{\nu}$$

$$R = \frac{1.91 \times 0.2}{6.67 \times 10^{-8}}$$

$$\boxed{R = 5.72 \times 10^{6}}$$

Now,

$$f = 0.0032 + \frac{0.221}{(5.72\times10^{6})^{0.237}}$$

$$f = 0.0032 + (5.5320 \times 10^{-3})$$

$$\boxed{f = 8.73209 \times 10^{-3}}$$

Now From Bernouli's Equation,

Head Loss, $H_F = \frac{fLV^2}{2gD}$

putting values

$$H_F = \frac{fLV^2}{2gD}$$

$$= \frac{(8.73209\times10^{-3})(500)(1.91)^2}{2\times(9.81)(0.2)}$$

$$H_F = 4.0590$$

Now we know by pressure loss and Head Loss relation,

$\Rightarrow \quad h_f = \frac{\Delta p}{\gamma}$

$\Rightarrow \quad h_f = \frac{\Delta p}{\rho g}$

$\Rightarrow \quad \Delta p = h_f \rho g$

$\Rightarrow \quad \Delta p = 4.0590 \times 900 \times 9.81$

$\Rightarrow \quad \Delta p = 35837.47 \text{ pa}$

$\Rightarrow \quad \boxed{\Delta p \quad 35.837 \text{ kpa}}$

Resolt :-

Hence pressure Loss,

$\Delta p = 35.837 \text{ kpa}$